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FLUE GAS CONDITIONING FOR IMPROVED PARTICLE COLLECTION IN ELECTROSTATIC PRECIPITATORS

Quarterly Technical Report

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PROGRAM OBJECTIVES

The purpose of this research program is to identify and evaluate a variety of additives capable of increasing particle cohesion which could be used for improving collection efficiency in an ESP. A three-phase screening process will be used to provide the evaluation of many additives in a logical and cost-effective manner. The three step approach involves the following experimental setups:

1. Provide a preliminary screening in the laboratory by measuring the effects of various conditioning agents on reentrainment of flyash particles in an electric field operating at simulated flue gas conditions.
2. Evaluate the successful additives using a 100 acfm bench-scale ESP operating on actual flue gas.
3. Obtain the data required for scaling up the technology by testing the two or three most promising conditioning agents at the pilot scale.

The objectives of this program will be attained by successfully completing the following technical tasks:

ACTIVITIES COMPLETED

TASK 2. SELECTION OF ADDITIVES

Various polymers and natural compounds were researched during this quarter for their suitability as ESP additives. The major requirements of low toxicity and temperature stability were specifically noted. These compounds are:

- Starches
- Gums
- Chitin
- Cellulose Derivatives
- Vegetable Oils
- Animal Fats

- Waxes
- Mineral Oil
- Polyacrylamide
- Poly(ethylene glycol)
- Poly(propylene glycol)
- Poly(vinyl pyrrolidone)
- Vinyl Alcohol Polymers
- Acrylics

1. Starches

Starch is a natural polymer consisting of glucose units chemically bound together to form a nonrecurring polyhydroxy material. Starch granules consist of para-crystalline solids, and range in size from 1 to 100 microns. Most of the starch used in the U.S. is produced from corn, *Zea mays*, and consists of amylose and amylopectin. Amylose is a straight chain molecule utilizing 1,4 linkages. Amylopectin is a branched molecule utilizing 1,4 and 1,6 linkages.

Starch-based adhesives are used in papermaking, paper coating, corrugating, bag adhesives, laminating adhesives, tube winding, case sealing adhesive, gummed tapes, label and envelope adhesives, textiles, wall covering adhesives, and various other applications.

In 1980, 5% of the U.S. production of corn (21×10^6 m^3 or 6×10^8 bushels) was ground for starch.

a. Waxy Corn Starch

Waxy corn starch contains only amylopectin. It is water soluble, and due to the high amylopectin content, tends to form weak, water sensitive films. Waxy corn starch is the basis for jelly gums, which are used in bottle labeling. Waxy corn starch is non-toxic, and can be used as a food additive or as an adhesive.

b. Corn Starch

Regular corn starch contains 72% amylopectin and 28% amylose. It is water soluble, non-toxic, and is a food additive. Corn starch must be heated or alkali treated to release starch molecules from granules.

The price of bulk corn starch was $0.17-0.18/kg in 1979.

c. Corn Syrup

Corn syrup is produced from the partial hydrolysis of corn starch into dextrose, maltose and higher molecular weight saccharides. It is a clear, colorless, viscous liquid.

The price of corn syrup was $0.32/kg in 1980.

d. Corn sugar (dextrose)

Dextrose is the most abundant sugar in nature. It can be produced from the complete hydrolysis of corn starch. Dextrose is a pure crystalline solid. It is water soluble and non-toxic, and is used as a food additive. The melting point of dextrose is 295°F.

The price of corn sugar in 1980 was $0.59/kg.

e. Dextrins

Dextrins, or starch gums, are derived from starch. Dextrins have high affinity for polar compounds such as water due to the large number of hydroxyl groups on the chain. The process of dextrinization, a type of hydrolysis, is accomplished using dry heat in the presence of acids. Depending upon the temperature and amount of acid used, several types of dextrins are formed. In general, all dextrins are water soluble and non-toxic. Dextrins are used widely as adhesives in food packaging.

A selection of Dextrin based adhesives can be obtained from Swift adhesives. Temperature, strength, and viscosity can be adapted for specific applications.

White Dextrin--White dextrins are prepared by heating starch and large amounts of acid to 258°F for 3-7 hrs. The color is white to cream, and the solubility and viscosity varies. They are used in tube winding, case and carton sealing, laminating, gummed sheets, label and envelope back seam adhesives.

Canary Dextrin--Canary dextrins are prepared by heating starch and moderate amounts of acid to 300°F for 11 hrs. They are very light to dark tan in color, have a high cold water solubility and a low viscosity. They are used in gummed tape, envelope front seals, stamps, case and carton sealing, laminating and tube winding.

British Gums--British gums are prepared by heating starch with a low amount of acid at 330°F for 17 hrs. They are dark in color and have varying solubilities and varying

viscosities. They are used solid fiber laminating, bag-seam pastes and tube winding adhesive.

2. Gums

Gums are hydrophilic polysaccharides derived from plants or microorganisms which produce viscous mixtures or solutions. Natural gums are carbohydrate in nature, and vary considerably in the details of their chemical structure. Technically, natural gums include starches and celluloses, but they are considered separately in this discussion.

Natural gums include plant exudates (gum arabic), seed gums (guar gum, locust bean gum), plant extracts, seaweed extracts (agar, carrageenan) and the extracellular microbial polysaccharides (xanthan gum). These natural gums are harvested and produced in an organized way by the chemical industry, so are available in a variety of grades.

Gums are used in detergent and laundry products, textiles, adhesives, paper, paint, food, pharmaceutical and cosmetics industries.

a. Gum Arabic

Gum arabic is an exudate from the acacia tree. It forms as 'tear drops' of exudate from wounds in the bark of the tree. It is a branched polymer of galactose, rhamnose, arabinose and glucoronic acid. Gum arabic usually contains calcium, magnesium and potassium salts, and has a molecular weight of 250,000 to 300,000.

Gum arabic is very soluble in cold water, and its solutions have a very low viscosity. These solutions have distinct adhesive properties.

Gum arabic is used in the food and pharmaceutical industries where it is used as an edible binder. It is also used in lithographic printing as a light-sensitive coating when mixed with potassium dichromate. It is non-toxic, although it can possibly act as a weak allergen.

The price of bulk gum arabic was $1.58-2.53/kg in 1979. Very pure samples of gum arabic can be purchased from Sigma Chemical at $5.00/100g.

b. Locust Bean Gum (Carob Bean Gum)

Locust bean gum is derived from seeds of *Ceratonia siliqua*. Locust bean gum is a galactomannan polysaccharide, which is a straight chain polymer of mannose with one galactose branch on every fourth mannose.

Locust bean gum is partly soluble in cold water, but completely soluble in hot water. It is nonionic in character, and gels can be formed with alkaline borates or mixing with carrageenan extract.

Locust bean gum is used in the food, papermaking, textile sizing and printing, and cosmetics industries. It is non-toxic, and is used as a stabilizer food additive and thickener. The price of bulk gum was $2.31-2.42/kg in 1979. Pure gum can be purchased from Sigma Chemical for $5.00/500g.

c. Guar Gum

Guar gum is an extract from the seeds of *Cyanopsis tetragonolubus*, a leguminous plant cultivated in Pakistan, India and Southwest United States. The extracted gum consists of a mannose polymer with galactose branches on every 2nd unit. This makes it very similar to locust bean gum. It is soluble in cold water, and the solutions have a high viscosity. Some commercial guar gum products have a slight degree of chemical modification to improve solubility in cold water or other properties. A company named Hi-Tek Polymers produces guar gum with various types of modifications.

Guar gum is used in the same way as locust bean gum, but supplies of guar gum are more regular and reliable, and also cheaper. It is used in the food, papermaking, mining, and petroleum industries. It is a non-toxic, stabilizer food additive and thickening agent.

The price of unmodified guar gum was $0.99-1.76/kg in 1979. Pure gum can be purchased from Sigma Chemical for $5.20/250g.

d. Carrageenan (Vegetable Gelatin)

Carrageenan is an extract from Irish moss, the red seaweed *Chondrus crispus*. It contains two main polymeric fractions; kappa-carrageenan and gamma-carrageenan. Both are sulfated polysaccharides (anhydrogalactose-galactose polymer sulfate ester). Carrageenan is soluble in water, forming viscous solutions.

Carrageenan is used in the pharmaceutical and cosmetics industries. It is used extensively in the food industry as a stabilizer food additive in many 'instant' foods.

Pure carrageenan can be purchased from Sigma Chemical for $13.75/100g.

e. Algin (alginic acid, alginate)

Algin is the main carbohydrate polymer in brown seaweeds, especially *Macrocystis pyrifera, Laminaria and Ascophyllum nodosum*. Algin is a linear polymer of mannuronic and guluronic acids. Alginic acid is nearly insoluble in water but is strongly hydrophilic. Sodium alginate dissolves in cold water, making somewhat viscous solutions. Propylene glycol alginate is soluble in water and has distinct commercial importance. Alginate solutions have very good flow properties, which is why they are used in industrial applications.

The textile industry is the major user of alginates. Solutions of the gum can be adjusted in viscosity and flow properties to suit many kinds of printing machinery and fabric texture. Alginates are also used in medicine and as a food stabilizer. They are also used for paper coating, photographic and lithographic purposes.

f. Agar (Gum Agar)

Agar is an extract from the red seaweeds *Gelidium* and *Gracilaria*. Normal samples of agar contain more than one polymeric substance. The main polymer is agarose, which contains galactose alternating with units of 3:6-anhydrogalactose. The second component is called agaropectin, which contains some sulfate ester groups. Agar is insoluble in cold water, but readily soluble in boiling water. Upon cooling the solution remains liquid until about 40°C is reached, when the mass sets to a very strong gel. The gel does not melt again until about 95°C is achieved (temperature hysteresis).

Much of the agar produced is used in the food industry as a gelling agent and a stabilizer food additive. Agar is used in the dentistry, medicine and microbiology industries also.

The price of bulk agar was $12.67-14.87/kg in 1979. Pure agar can be purchased from Sigma Chemical for $12.90/100g.

g. Xanthan Gum

Xanthan gum is an extracellular polysaccharide produced by fermentation of dextrose with *Xanthomonas campestris*. It is unusual polysaccharide polymer of glucose, mannose, potassium glucoronate, acetate and pyruvate. It is soluble in cold water and forms viscous solutions.

Xanthan gum is used in oil well drilling muds, because of its heat stability and tolerance of salts. It is also used in certain textile dyeing systems and in the pharmaceutical industries. Purified xanthan gum is an approved food additive.

The price of bulk xanthan gum was $6.37-8.82/kg in 1979. It can be purchased in very pure form from Sigma Chemical for $11.05/100g.

3. Chitin

Chitin is the fibrillar polymer formed from linked acetamido-2-deoxy-D-glucopyranose units. Chitosan is a term used when the nitrogen content is greater than 7%. Chitin and chitosan are the only naturally occurring polysaccharides which are basic in character.

Chitin is isolated from a large number of organisms, including insects, fungi and crustaceans. Chitin and its derivatives are known to occur in natural adhesive systems, such as barnacle adhesive. Chitosan salt solutions are known for their adhesive properties, and will adhere to paper, rayon, cellophane, wood, leather, rubber, and glass.

4. Cellulose Derivatives

Cellulose is the major chemical constituent of plants. It is a homogeneous polysaccharide formed from glucopyranose units linked together. It is a semicrystalline polymer, and cannot be melted before it burns.

Hemicellulose is a noncrystalline group of heterogeneous polysaccharides which are the second-most abundant source or carbohydrates in plants. They are located in the cell wall of plants and in the bast fibers of bark.

Commercial production of cellulose derivatives is concentrated on the pure sources like cotton or easily harvested sources like wood.

a. Methylcellulose

Methylcellulose is a class of water soluble cellulose ethers derived from cellulose. They are used in foods, cosmetics, pharmaceuticals, latex paints, construction products, and ceramics. They are used as thickeners, binders, film formers, water retention agents, suspension aids, surfactants, lubricants, protective colloids and emulsifiers. One unusual characteristic of these compounds is the ability to thermally gel.

There are various types and grades of methylcelluloses, each having unique properties. The two types available from Dow Chemical Corp. are methylcellulose and hydroxypropyl methylcellulose. Both are made by the reaction of wood or cotton cellulose fibers with chemical reactants in the presence of a caustic soda. The product is then purified and ground into a fine powder. Methylcellulose is made using methyl chloride while hydroxypropyl methylcellulose is made using propylene oxide and methyl chloride.

Methylcelluloses are soluble in cold water, non-ionic, stable over a wide pH range, have little odor, and are metabolically inert. Aqueous solutions of methylcelluloses gel when heated above a particular temperature, then go back into solution upon cooling. The viscosity ranges from 3 to 100,000 mPa·s for various types and grades.

Both types of premium cellulose derivatives are recognized as acceptable food additives by the U.S. Food and Drug Administration. Methylcellulose is considered Generally Recognized As Safe by the FDA. Standard grades of the cellulose derivatives have more impurities and are not approved for use in foods, but can be used in food packaging.

The char temperature for methylcellulose is around 437°F. The bulk price for methylcellulose was $3.37-4.63/kg in 1979. Dow Chemical Coatings and Resins Dept. were contacted, and information was sent on Methocel, a methyl cellulose polymer which is water soluble.

b. Sodium Carboxymethylcellulose

Sodium carboxymethylcellulose, or SCMC has a hydroxyl group of the glucose units of the cellulose polymer chain reacted to form a carboxymethyl ether. The properties of SCMC vary with the degree of substitution. Typically, SCMC is soluble in cold water, and is ionic in character, making it somewhat like sodium alginate.

SCMC is the cellulose gum used on the largest scale. A large amount of inexpensive SCMC is used in the formulation of synthetic detergents. The textile industry uses SCMC as a size for warp threads and for thickening textile printing pastes. SCMC is used as an adhesive for wallpaper, for thickening oil well drilling muds, for manufacture of synthetic latex, and in lithographic printing. SCMC of high purity is widely approved as a food additive and stabilizer.

The char temperature of SCMC is 486°F. The price of bulk SCMC was $1.68-2.54/kg in 1979, making it cheaper than methylcellulose.

5. Vegetable Oils

Most oils and fats are composed of a group of closely related compounds, the triglycerides. Triglycerides are formed by the reaction of the trihydric alcohol glycerol and fatty acids. Most of the fatty acids in natural oils occur as straight chains containing 12 to 18 carbon atoms. A few shorter chain acids are found in milk fats, while longer chains are found in certain types of fish oils.

The properties of oils and fats are due to the properties of the component glycerides and their fatty acids.

a. Soybean Oil

Soybean oil is derived from the seeds of *Glycine max*. This is a leguminous plant native to China, but cultivated widely in the U.S. Crude soybean oil contains high levels of phosphatides (lecithin) and is greenish yellow in color. Refined and deodorized soybean oil is used for all edible purposes but does not give as good results as the other liquid oils such as corn oil. Large amounts of soybean oil are hydrogenated to form the basis of margarine, shortening, and other cooking fats.

Soybean oil has a flash point 540°F. The bulk price of soybean oil was $539/ton ($0.59/kg) in 1977. Soybean oil is $0.18-0.20/lb according to Wall Street Journal.

b. Palm Oil

Palm oil is extracted from the oil palm *Elaeis guineensis*. This plant produces a fruit which provides two different oils. The pulp contains palm oil which is composed mainly of C16 and C18 fatty acids and behaves like most other vegetable oils apart from its high melting point. Within the pulp are kernels which provide the source material for palm kernel oil, which is similar to coconut oil.

Palm oil is used extensively for the production of margarine and shortening. It is high in saturated fatty acids. Palm oil is inexpensive ($0.22/lb) according to Wall Street Journal.

c. Linseed Oil

Linseed oil is obtained from the seeds of the flax plant, *Linum usitatissimum*. Linseed oil contains mostly linolenic acid, but also linoleic and oleic acids. The oil is golden yellow with a pleasant, characteristic odor.

Linseed oil is used in paint, varnish, printing inks and linoleum. It is used in the U.S. as a treatment for concrete to protect against frost. Linseed oil is considered a mild irritant.

The boiling point of linseed oil is 649°F, while the flash point 432°F. Bulk linseed oil was $400/ton ($0.44/kg) in 1977.

d. Castor Oil

Castor oil is obtained from the seeds of the castor plant *Ricinus communis*. Castor oil differs from other vegetable oils in that its main component fatty acid is a hydroxy acid, ricinoleic acid. This gives the oil a high viscosity and specific gravity.

Castor oil is used in medicine, cosmetics, as a lubricant or as a plasticizer for nitrocellulose lacquers. Modified castor oils are used in other industrial applications. Castor oil is also used in making nylon-11 and polyurethanes.

The flash point of castor oil is 445°F. The price for bulk castor oil was $0.145/kg in 1975.

6.Animal Fats

a. Lard (Pork Fat)

A high proportion of the animal fats produced is lard, which is the fat produced by rendering the fatty tissues of pigs. The composition and characteristics of lard are variable.

The flash point of lard is 395°F for crude, 500°F pure. Lard is usually cheaper than vegetable oils. One possible adulterant is tallow, which is cheaper than lard. It was $613/ton ($0.31/lb) in 1977, and is currently $0.12-0.13/lb; Wall Street Journal.

b. Beef Tallow (Beef Fat)

Beef tallow is obtained from the body tissues of cattle. Much of the tallow produced is now used for non-edible purposes in the United States. It is used extensively for food purposes in other countries.

Beef tallow has a flash point of 509°F. The price of bulk tallow was $377/ton ($0.18/lb) in 1977, and is currently $0.12-0.14/lb, according to the Wall Street Journal.

7. Waxes

a. Carnauba Wax (Palm Wax)

Carnauba wax occurs as a fine powder on the leaves of certain tropical palm trees, especially *Copernicia cerifera*. The leaves are removed from the tree, dried in the sun, and then the powdery wax is brushed off and placed in vats of boiling water. The wax is then skimmed off the vat and treated further. There are various grades of carnauba wax. Carnauba wax is amorphous, hard, lustrous, and has a pleasing odor. It is a mixture of hydrocarbons, higher alcohols and their esters.

Carnauba wax is used in candles, polishes, lubricants, greases, floor and automobile waxes, insulating materials, soaps, salves, plastics, cosmetics, protective coatings and paper coating. It has low toxicity, and is a general purpose food additive.

Carnauba wax has a flash point 540°F, and a melting point 185° F. The price of bulk carnauba wax was $1.87/kg in 1981. Pure samples can be purchased from Sigma Chemical for $7.20/100 g.

b Paraffin Wax (Petroleum Wax)

Paraffin wax is a white, translucent, tasteless and odorless solid. It consists of a mixture of solid hydrocarbons chiefly of the methane (paraffin) series obtained from petroleum. Paraffin wax is sold in various grades which differ from one another mostly on melting point. The largest percentage of paraffin wax sold is the refined type. The remainder is crude scale wax, which differs from refined wax in that it contains more oil (3%). This makes the wax softer and more crumbly, and the taste and odor are more noticeable.

Paraffin wax has a flash point of 390°F, and an autoignition temperature of 883°F. Paraffin wax is an experimental carcinogen of the lung and stomach.

Paraffin wax is produced by nearly all oil companies. The price for bulk paraffin wax was $0.40/kg in 1981.

c. Microcrystalline Wax

Microcrystalline wax is also derived from petroleum, but through a solvent extraction process, not distillation. It differs from refined paraffin wax in crystal size and

structure. It is tougher, more flexible and has a higher tensile strength and melting point. Microcrystalline wax is also more adhesive and less lustrous and greasy than paraffin wax.

The oil content of microcrystalline wax varies with the grade of wax, but is usually 2-12%. The molecular weight of microcrystalline wax is 580-700, and contains straight chain molecules as well as a large proportion of branched-chain molecules. This accounts for the plasticity of microcrystalline wax when compared to paraffin wax.

Microcrystalline waxes usually melt at 145-195°F. The flash point >400°F. It has a low toxicity.

Microcrystalline waxes are used in waterproofing paper, box-board, textiles, leather, wood, laminating paper, etc., rubber compounding, slushing compounds, polishes, paper making, binder for pipe coverings, filler for packings, drum linings, and vat linings.

8. Mineral Oil (Paraffin Oil)

A mixture of liquid hydrocarbons from petroleum. Flash pt.: 444°F. Inhalation of vapor or particulates can cause aspiration pneumonia. Mineral oils are recognized carcinogens of the skin and scrotum. Also experimental carcinogens of the larynx, lung and alimentary tracts. Relatively low cost. Sigma Chemical: $6.20/1000ml.

9. Polyacrylamide

Polyacrylamide is a water soluble polymer used as a food additive. It has a low toxicity, although the monomer is highly neurotoxic. Polyacrylamide gives off ammonia above 480°F.

Polyacrylamide is used in water treatment, paper making, mineral processing, and enhanced oil recovery. The nonionic polymer costs $2.00/kg. Polyacrylamide is produced by Dow Chemical, Exxon, Betz, and American Cyanamid.

10. Poly(ethylene Glycol)

Poly(ethylene glycol), or PEG, is a polymer of ethylene oxide which can be represented by the general formula $HO(CH_2CH_2O)_nH$, where n represents the average number of ethylene oxide units. They are linear polymers containing two terminal primary hydroxyl groups. PEG is water soluble, non-toxic, and have little odor.

Variations in physical properties are due to molecular weight. As molecular weight increases, viscosity and freezing point increase while solubility decreases.

Methoxypropylethylene glycol is produced by the addition of a terminal methyl group and a terminal primary hydroxyl group. Many of the physical properties of the MPEGs are similar to PEG.

PEG is used as both a direct and indirect food additive. It is also used in pharmaceutical industry as a tablet coating, and as a base for ointments, lotions, and suppositories. PEG is also used in the cosmetics/toiletries industry in products such as toothpaste, soap, dentifrices, cake makeup, cream rouge, shaving cream, hand lotion, suntan lotion, hair dressings and conditioners, mascara, bath oils, emollients, cosmetic and antiperspirant sticks, and skin cleaning paste. PEG is also used in the rubber industry as a mold release agent and lubricant, as a binder for ceramics, and in the paint, paper, metal fabrication, textiles, and electronics industries.

11. Poly(propylene Glycol)

Polypropylene glycols (PPG) are polymers of propylene oxide and can be represented by the general formula $HO(CH_2CH(CH_3)O)_nH$, where n is the average number of propylene oxide groups. PPG is a clear, viscous liquid with low pour points. Viscosity increases with molecular weight. The lower molecular weight PPGs are soluble in water at room temperature, while the higher molecular weight PPGs have limited solubility in water. Dow Chemical PPGs meet the requirements of the FDA indirect food additive regulations listed in the FDA/EPA Status Selection.

PPGs are used as antifoam agents, lubricants, hydraulic fluid lubricants, heat transfer fluids, cosmetics and dust adhesive fluids, which are applied to air filters, dust mops, dust cloths, etc. to pick up and hold soil particles.

12. Poly(n-vinyl-2-pyrrolidinone)

Poly(n-vinyl-2-pyrrolidinone) or PVP, is a polymer which is highly soluble in water and many solvents, and readily forms complexes. I has a molecular weight of 2,500-7,000 X 10^5 for most commercial grades. The viscosity of aqueous solutions of PVP is low compared with other polymers. It fulfills the function of a protective colloid in many cases. It can form films and shows a good adhesion on many materials.

PVP is non-toxic, and is used in the pharmaceutical industry as a synthetic blood serum, a binding agent for tablets, and as a complexor with drugs. The cosmetics industry uses PVP in hair sprays, shampoos, hair rinses, shaving soaps and lotions, creams and toothpastes. PVP is also used in the textile industry, as a clarifier for wine and beer, in soap, detergents, polishing agents, water-soluble adhesives and ink. It is also used as a food additive. PVP is essentially an inert material and is non-hazardous when inhales.

The price of PVP was $3.20-3.50/kg in 1981. GAF Corporation is the only producer of PVP in the U.S. although BASF sells resin imported from Germany. 2000-4000 tons/yr are produced in the U.S.

13. Vinyl Alcohol Polymers

Poly(vinyl alcohol) or PVA is a water soluble polyhydroxy polymer. It is produced by the hydrolysis of poly(vinyl acetate), and was discovered in 1924. PVA is an excellent adhesive and has low surface tension, high tensile strength and abrasion resistance. The physical properties of PVA depend to a great extent on the method of preparation, which includes the polymerization conditions of the parent poly(vinyl acetate) as well as the hydrolysis conditions, drying and grinding. The viscosities of PVA solutions are dependent on molecular weight, concentration, hydrolysis and temperature. The surface tension of aqueous solutions of PVA varies with concentration, temperature, degree of hydrolysis and acetate distribution on the PVA backbone.

PVA is a nonhazardous material according to the American Standard for Precautionary Labeling of Hazardous Industrial Chemicals. It has a low oral toxicity rating (rats), and low toxicity in bluegill sunfish at concentrations of 10,000 mg/l in water. Short-term inhalation of PVA dust has no known health significance but can cause discomfort and should be avoided as a one would a nuisance dust. PVA is also one of the few completely biodegradable synthetic polymers when treated with an activated sludge.

The main uses of PVA are in fibers, adhesives, emulsion polymerization, production of poly(vinyl butyral), and textile and paper sizing. Other uses are as joint cements for building construction, water-soluble films for hospital laundry bags, emulsifiers in cosmetics, solid binding for erosion control, and cold water-soluble packaging for pesticides, herbicides and fertilizers.

The principal PVA producers are Air Products and Chemicals, Inc. and DuPont. The price has historically reflected the cost of ethylene, acetic acid, and energy. It was $0.77/kg in 1970 and $2.75/kg in 1988 for a medium mol wt grade.

Air Products and Chemicals, Inc. was contacted in January, and literature on their line of PVAs and their current uses was sent.

14. Acrylics

Acrylic adhesives are based mainly on ethyl, butyl and 2-ethyl hexyl acrylate monomers, plus small quantities of methyl methacrylate and acrylic or methacrylic acids. Frequently the acrylic monomers are copolymerized with other vinyl monomers such as vinyl acetate, vinyl chloride, or styrene. This permits the synthesis of linear polymers of very high molecular weight. Water soluble polymers can be made through proper monomer and functional group selection. Emulsions of other, non-water soluble acrylics can also be made.

The viscosity of the polymer solutions increases directly with molecular weight. Acrylic adhesives have low toxicity and high water resistance.

Acrylic polymers are widely used as adhesives for pressure sensitive tapes, labels, and other pressure sensitive products. Acrylics are also used in a variety of waterborne construction adhesives, laminating adhesives, and packaging adhesives.

Air Products and Chemicals, Inc. was also contacted for information on acrylics. Their representative indicated that the high temperature of the ESP would not be a problem for their products. Information on their products was also sent.

PLANS FOR NEXT QUARTER

All plans for the next quarter are contingent upon obtaining approval of the Environmental Assessment (EA) for the project so that the scheduled activities can proceed as planned. If the EA is not approved, then work on the project will be halted.

When the EA is approved, work will begin in both Task 3 and Task 4. In Task 3, the experimental equipment required for the laboratory testing will be designed and assembled. In Task 4, the auxiliary equipment to operate the bench-scale ESP will be designed.

END

DATE
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